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PLASMA AND MAGNETOSPHERIC RESEARCH

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by

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ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

A significant area of progress this period has been the further development of the two-dimensional kinetic model for the cleft ion fountain. During this period, we have developed the formalism and software to use the ion trajectory code to obtain distribution functions, which are then integrated to get moments such as density, parallel fluxes and parallel average energy. These moments have been contoured in a spatial grid through the polar magnetosphere to display their distribution; and the distribution functions have been contoured in velocity space. We have also included a parallel electric field distribution to simulate the possible effect of an ambipolar electric field, although this has not been done self-consistently in that we do not explicitly incorporate the electron equations.

The RIMS thin sheath analysis program is undergoing extensive revision with the first part in final stages of debugging. This part has involved two significant improvements in the analysis. The first is incorporation of the saturation correction, which has been developed within the data analysis group. This correction ties in to software developed for other programs, which contains a means for calibrating the effect for different time periods. The second improvement employs the spin modulation of the unretarded data as independent information to complement the RPA data from the ram direction, which is presently used. The motivation here is to resolve an ambiguity that has persisted in the analysis of RPA data for positive spacecraft potentials. Initial tests have shown good results for simulated data. It appears that the best approach is to determine the temperature from the RPA curve and the spacecraft potential from the spin

curve. Modifications of this procedure may make it possible to improve the analysis of data taken after the radial RPA ceased functioning properly.

Development of a program for carrying out a statistical analysis of ion temperature ratios has been initiated. This will be a prototype for other statistical programs operating on output files from the RIMS thin sheath analysis programs.

DATA ANALYSIS AND MODELING

The analysis of molecular ion observations has been completed and a paper on this work has been submitted for publication (Ref. 1). Field-aligned flows of cold (1000-2000 K) molecular nitrogen (N_2^+), molecular oxygen (O_2^+) and nitric oxide (NO^+) ions have been inferred over the polar cap. Ion densities of 1-2 cm^{-3} are observed, with flow velocities of 5-15 km/s (up to 20 eV kinetic energy). These results were also reported to the Fall AGU Meeting in San Francisco (Ref. 2).

Modeling of minor ions in the plasmasphere has continued. The significant results from recent runs show that for the geophysical conditions modeled, thermal diffusion of O^{++} is about a 10 % effect, even at high equatorial ion temperatures (8000 K). Ion drag due to the motion of the major ion O^+ dominates the terms in the O^{++} diffusion equation. The relative unimportance of thermal diffusion for O^{++} is due in part to the fact that the largest gradients in ion temperatures exist in the O^+ dominated region where the O^{++} thermal diffusion coefficient is small. This confirms the result obtained by Waite et al. (1984; Ref. 3). Although it has not been possible to recreate the results of Geiss and Young (1981), which showed O^{++} densities at the equatorial plane for L = 3 of 1 ion/cm,

the O^{++} density profiles obtained are in reasonable agreement with DE/RIMS observations. A paper on this work is in preparation (Ref. 4).

An effort is underway to determined the field-aligned ion velocity inside a micropulsation event. This event is being studied in detail by a group of scientists headed by Dr. M. Engebretson of Augsburg College, (some results were presented to the Fall AGU meeting (Ref. 5). Using RIMS data, we have determined through two independent methods that one component of this bidirectional flow is moving at about 20 km/s. We have also been able to use the RIMS data to show that there exists a DC offset of the order of 10 mV/m in the electric field measured by the PWI instrument. A paper on this work is in preparation (Ref. 6).

During the recent visit by U. Samir, the study of thermal ions in the wake of DE-1 was revised and extended. Ion fluxes in the ram direction were corrected for saturation effects, then a more extensive analysis was carried out. The dominant factor in the wake depletion appears to be the effect of the Mach number. When this is removed, the data scatter is not significantly ordered by any other parameter tested. DE/RIMS observations were found to be consistent with those of previous hypersonic ionospheric satellites, even though the flow regime was quite different (subsonic to transonic). Agreement between the observations and a simple neutral planar theory was surprisingly good. These results were reported to the Fall AGU Meeting (Ref. 7) and a paper on this research is in preparation (Ref. 8).

A comparison of DE-1 and ISEE-1 data has made it possible to determined that for one of the better examples of equatorial heating observed by DE-1, that satellite was approximately 0.1 R_E outside the plasmapause measured by ISEE-1. Although this circumstance had been

inferred from previous measurements, it can now be demonstrated conclusively for the first time.

Further analysis of the conical ion distributions found at 1-10,000 km altitude in the auroral regions shows that in addition to the light ions previously reported (H^+ and O^+), N^+ and molecular ions N_2^+, O_2^+, and NO^+ could also be found with perpendicular energies of 5-15 eV. These results were presented to the Fall AGU Meeting (Ref. 9).

Studies of the "cleft ion fountain" are progressing, and two papers on this topic are being prepared. The first (Ref. 10) contains primarily observations, but with some model ion trajectories, dealing with the distributions and characteristics of mainly low-energy O^+ in the polar magnetosphere as supplied by the upflowing ions at the cleft ionosphere. The second (Ref. 11) describes a two-dimensional kinetic model of the cleft ion fountain based on the trajectory code initially described in Reference 22. We envision these as companion papers in JGR and hope for them to have a major impact on the field. Two related papers were presented to the Fall AGU Meeting (Ref. 12, 13).

The study of the behavior of secondary ion streams around the space shuttle, based on Differential Ion Flux Probe (DIFP) measurements on STS 3, is almost completed. Data analysis is largely completed and preparation of a paper is ready to be initiated.

SPACECRAFT SHEATH EFFECTS

Progress has been made in the study of the spin modulation of the satellite potential observed on SCATHA. It has been shown that the particle measurements from the MSFC Light Ion Mass Spectrometer (LIMS) and the UCSD electrostatic analyzer vary with spin phase in the same way. It

has also been found that the short booms and long electric antennas register a one volt potential modulation with the same phasing inferred from the particle measurements.

In other areas, considerable effort was devoted to the completion of two papers, one on hidden ions (Ref. 14) and one on the aperture bias (Ref. 15), particularly in preparing the final figures. These have been submitted for publication.

LABORATORY PLASMA FLOW STUDIES

A laboratory experiment is being prepared to look at anomalous ionization. In this experiment, ions reflected from a positively biased conducting plate will be observed as the background neutral density is increased. A number of electrical and mechanical problems with the chamber system have been overcome, and the experiment should be ready to run shortly.

INSTRUMENT DEVELOPMENT

- Extension tubes were manufactured for the vacuum system.
- Faraday cup parts were modified.
- Printed circuit boards were cut for one of the instruments.
- Electrical conductors were made for the ion pump.
- Rings were built for Faraday cups.
- Lava parts were built for the redesigned ion gun.
- Fiberglass aperture boards were cut to size.
- Aluminum straps were built for a mounting fixture.

MEETINGS AND PRESENTATIONS

Dr. Olsen attended the ISTP Science Working Group meeting at GSFC, Greenbelt, MD, November 27-28, 1984.

Drs. Comfort, Horwitz, and Olsen attended the Fall AGU Meeting in San Francisco, CA, December 3-7, 1984, where they presented a number of papers. In addition to papers noted above, we participated as author or coauthor in the following papers presented to the Fall AGU Meeting: a paper on the effects of geomagnetic activity on plasmaspheric ion temperatures (Ref. 16), a paper on ion motions and electric fields during a Pc-5 event (Ref. 17), a paper on DE-1 and 2 conjugate measurements of plasmasphere and ionosphere structure (Ref. 18), a paper on elevated plasma temperatures in the space shuttle wake (Ref. 19), a paper comparing body-plasma interactions for the shuttle with those of small ionospheric satellites (Ref. 10), and a paper on upwelling O^+ ions (Ref. 21).

Initial steps have been taken by Dr. Chandler, supported by Drs. Comfort and Torr (Utah State University) to organize a special session on magnetospheric modelling at the 1985 Spring AGU Meeting.

PUBLICATIONS

In addition to those noted above, the following papers are at the indicated stage of the publication cycle.

Papers published: A study of ion trajectories in the polar magnetosphere (Ref. 22), an examination of residence time heating effect in auroral conic generation (Ref. 23), and a comparison of magnetic reconnection in solar flares and magnetospheric substorms (Ref. 24).

Papers accepted for publication: A study of the relationship of dusk sector electron energy dispersion to the electric field for off-equatorially mirroring electrons (Ref. 25), a study of electrostatic waves in the magnetosheath (Ref. 26), dynamics of magnetospheric plasmas (Ref. 27), a survey of plasmaspheric ion temperatures (Ref. 28), and a laboratory study of plasma expansion (Ref. 29).

Papers submitted for publication and in review: A study of high ion densities in the polar cap (Ref. 30), a study of the AKR emission cone (Ref. 31), plasma and wave observations of a Pc-5 event (Ref. 32), a study of plasmapause structure observed by ISEE-1 (Ref. 33), and a study of substorm characteristics during steady IMF (Ref. 34).

Papers in preparation: A comparative study of DE-1 and DE-2 plasmasphere and ionosphere observations (Ref. 35), and examination of inner magnetosphere plasma boundaries (Ref. 36), a description of the Spacelab 2 DIFP (REf. 37), a comparative study of ionospheric plasma disturbances caused by the space shuttle and small satellites (Ref. 38), and a study of the dusk bulge from conjugate observations of GEOS-2 and DE-1 (REf. 39).

A NASA TMX is also being prepared on Fabrey-Perot interferometer observations of the auroral thermosphere (Ref. 40).

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FINANCIAL DATA

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